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(54) **HYBRID HEAT PUMP APPARATUS**

(71) Applicant: **KYUNGDONG NAVIEN CO., LTD**, Pyeongtaek-si, Gyeonggi-do (KR)

(72) Inventor: **Dong Keun Lee**, Seongnam-si (KR)

(73) Assignee: **KYUNGDONG NAVIEN CO., LTD**, Pyeongtaek-si, Gyeonggi-do (KR)

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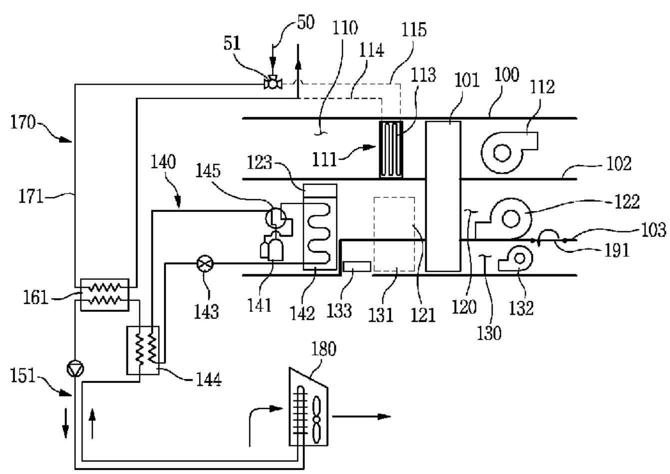
Primary Examiner — Davis Hwu
(74) *Attorney, Agent, or Firm* — Novick, Kim & Lee, PLLC; Jae Youn Kim

(57) **ABSTRACT**

The present invention relates to a hybrid heat pump apparatus comprising: a housing having a first channel and a second channel formed therein; a dehumidifying rotor disposed in the housing; a heating unit disposed in the first channel and heating air passing therethrough; a cooling unit disposed in the second channel and selectively cooling air passing therethrough; a coolant circulating unit including a compressor, a first heat exchanger disposed in the second channel, a second heat exchanger, and a four-way valve; and a water circulating pipe through which water circulates and which is connected to the second heat exchanger for heat exchanging between the circulating water and coolant in the second heat exchanger.

20 Claims, 6 Drawing Sheets



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F24F 3/14	(2006.01)
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(52) **U.S. Cl.**

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See application file for complete search history.

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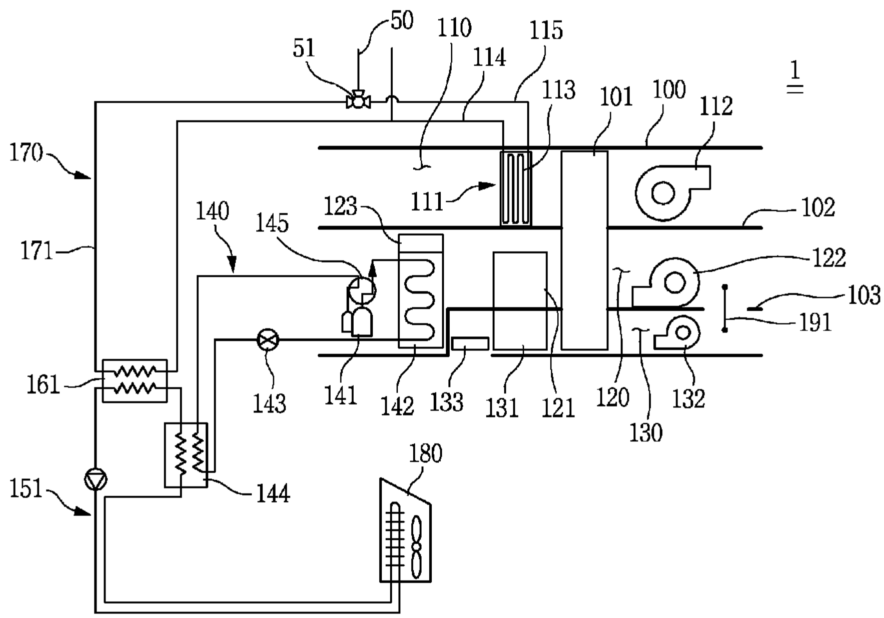

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FIG. 1

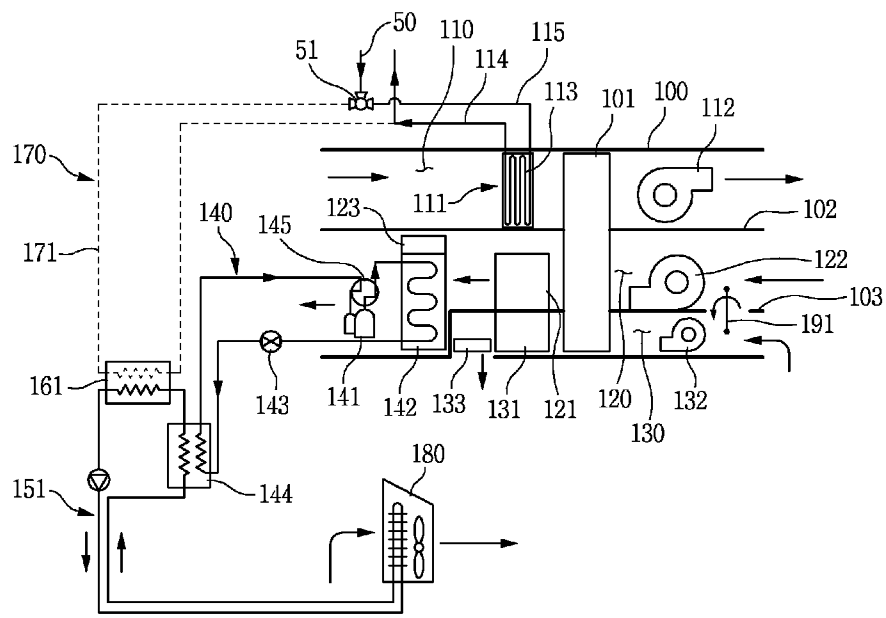
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FIG. 2

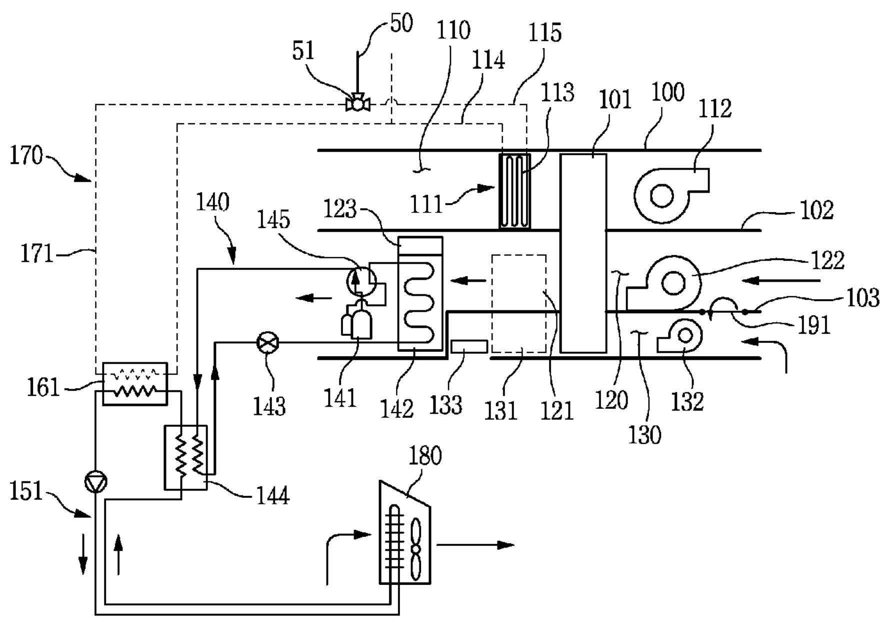
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FIG. 3

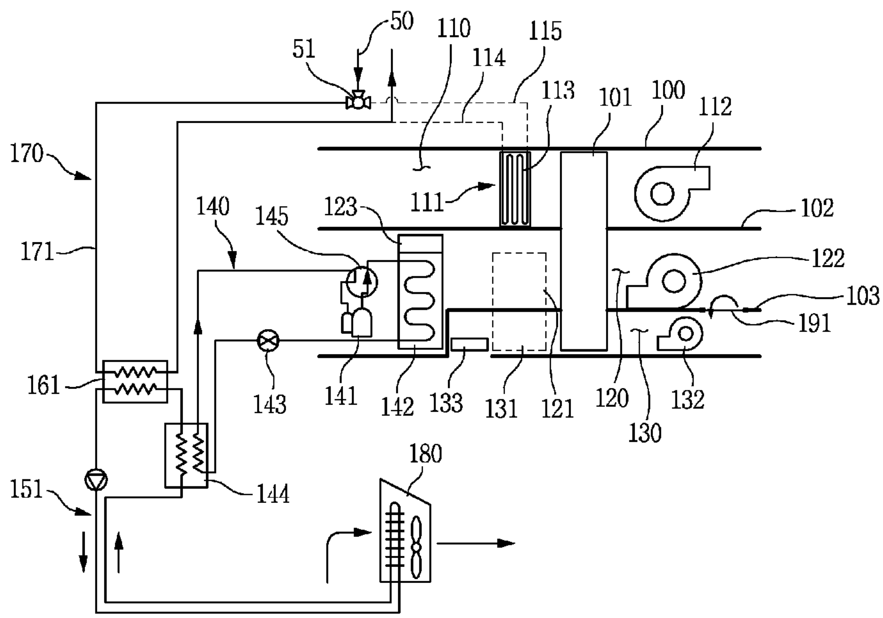

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FIG. 4

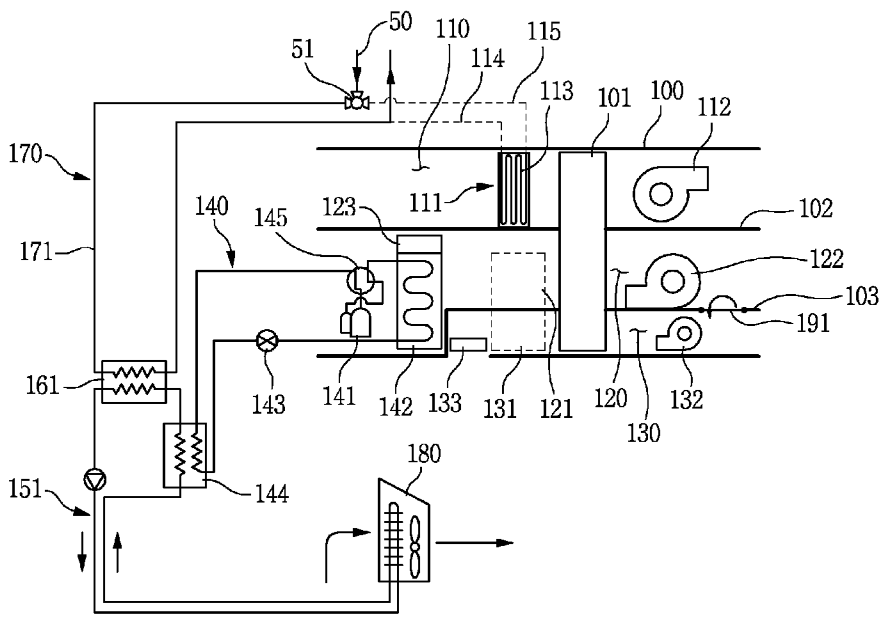
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FIG. 5

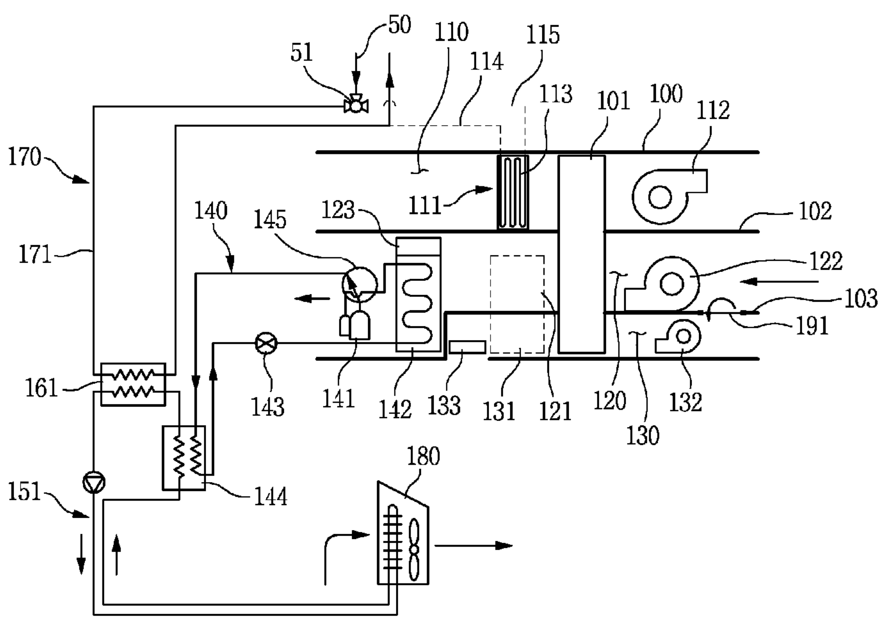
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FIG. 6

HYBRID HEAT PUMP APPARATUS

TECHNICAL FIELD

The present invention relates to a hybrid heat pump apparatus capable of performing both cooling and heating functions together with a dehumidification function.

BACKGROUND ART

Electric heat pumps are known as conventional cooling/heating apparatuses. Electric heat pumps are usually used as cooling/heating apparatuses since they may rapidly perform cooling and heating, be inexpensive, and be easily installed.

However, such electric heat pumps have a disadvantage in that a large amount of electric energy is consumed and heating performance is rapidly deteriorated as ambient air temperature is lowered. The electric heat pumps also have a problem in that it is impossible to perform a heating operation while they are operated in a defrost mode.

Meanwhile, dehumidifying and cooling techniques have been actively studied for interior cooling. A dehumidifying and cooling technique performs cooling by controlling a latent heat load using a dehumidifier and reducing temperature using evaporation heat.

In more detail, the dehumidifying and cooling technique performs a process of removing a latent heat load by removing moisture contained in air using a dehumidifier, and of evaporating the dehumidified and dried air by supplying moisture thereto so as to reduce the temperature of the air using evaporation heat, and performs cooling by forming a circulation cycle such that the process is repeated.

The dehumidifying and cooling technique is a new and renewable energy technique in terms of low energy consumption and eco-friendliness, and has been continuously developed.

By way of example of the dehumidifying and cooling technique, there is Korean Patent Application Publication No. 10-2012-0022684 entitled “Dehumidifying and cooling apparatus”.

The dehumidifying and cooling apparatus disclosed in the above patent application includes a housing, a dehumidifying module including a first casing, which is disposed in the housing and has interior and exterior passages formed therein by a partition wall, and a desiccant rotor, which is rotatably installed over the interior and exterior passages of the first casing, a regeneration module including a second casing, which is disposed in the housing and has interior and exterior passages formed therein by a partition wall, and a regenerator, which heats air passing through one of the interior and exterior passages, and a cooling module including a third casing, which is disposed in the housing and has interior and exterior passages formed therein by a partition wall, and a sensible rotor which is rotatably installed over the interior and exterior passages of the third casing, wherein the first to third casings are detachably mounted to the housing, and thus the housing has two channels which are partitioned from each other therein.

Conventional dehumidifying and cooling apparatuses including the above patent application have an advantage in terms of low energy consumption and eco-friendliness.

However, the dehumidifying and cooling apparatuses have a disadvantage in that they are applicable only to a structure having equipment (e.g. an air circulation duct) through which air cooled by passing through a dehumidification passage may be supplied back to the inside thereof.

In addition, the structure must be further provided with a separate blower which allows cooling air to be smoothly circulated along a supply path thereof. The blower must be usually a blower having high static pressure and high airflow. For this reason, the conventional dehumidifying and cooling apparatuses also have a disadvantage of increasing electricity consumption.

Moreover, the conventional dehumidifying and cooling apparatuses may be used for only interior cooling. Hence, there is a problem in that heating apparatuses such as the above electric heat pumps must be separately provided for interior heating.

DISCLOSURE

Technical Problem

The present invention has been made in view of the above-mentioned problems, and it is an object of the present invention to provide a hybrid heat pump apparatus to which a dehumidifying and cooling technique is applied. In addition, the hybrid heat pump apparatus can be also applied to a structure which is not provided with an air circulation duct, and can perform both cooling and heating functions.

Technical Solution

In accordance with a first aspect of the present invention, there is provided a hybrid heat pump apparatus including a housing, a first channel formed in the housing such that first air passes through the first channel, a second channel formed in the housing such that second air passes through the second channel, a desiccant rotor rotatably installed in the housing while being disposed over the first and second channels, so that the desiccant rotor is dried by the first air passing therethrough and absorbs moisture from the second air passing therethrough, a heating unit disposed upstream of the desiccant rotor so as to be closer to an introduction side of the first air in the first channel, the heating unit serving to heat the first air passing therethrough, and a cooling unit disposed downstream of the desiccant rotor so as to be closer to a discharge side of the second air in the second channel, the cooling unit serving to selectively cool the second air passing therethrough. In addition, the hybrid heat pump apparatus includes a refrigerant circulation unit including a compressor, a first heat exchanger, a second heat exchanger, and a four-way valve, the first heat exchanger being disposed downstream of the cooling unit so as to be closer to the discharge side of the second air in the second channel, a refrigerant being circulated in the refrigerant circulation unit in order of the compressor, the first heat exchanger, the second heat exchanger, and the compressor or vice versa, according to control of the four-way valve, and a water circulation pipe in which water is circulated, the water circulation pipe being connected to the second heat exchanger such that the water circulating therein exchanges heat with the refrigerant in the second heat exchanger.

In accordance with a second aspect of the present invention, there is provided a hybrid heat pump apparatus including a housing, a first channel formed in the housing such that first air passes through the first channel, a second channel formed in the housing such that second air passes through the second channel, a third channel formed in the housing such that third air passes through the third channel, a desiccant rotor rotatably installed in the housing while being disposed over the first, second, and third channels, so that the desiccant rotor is dried by the first air passing therethrough and absorbs moisture from the second air and the third air passing therethrough, a heating unit disposed upstream of the desiccant rotor so as to be closer to an introduction side of the first air in the first channel, the heating unit serving to heat the first air passing therethrough, a first cooling unit disposed downstream of the desiccant rotor so as to be closer to a discharge side of the second air in the second channel, the first cooling unit serving to selectively cool the second air passing therethrough, and a second cooling unit disposed downstream of the desiccant rotor so as to be closer to a discharge side of the third air in the third channel, the second cooling unit serving to cool the third air passing therethrough. In addition, the hybrid heat pump apparatus includes a refrigerant circulation unit including a compressor, a first heat exchanger, a second heat exchanger, and a four-way valve, the first heat exchanger being disposed downstream of the cooling unit so as to be closer to the discharge side of the second air in the second channel, a refrigerant being circulated in the refrigerant circulation unit in order of the compressor, the first heat exchanger, the second heat exchanger, and the compressor or vice versa, according to control of the four-way valve, and a water circulation pipe in which water is circulated, the water circulation pipe being connected to the second heat exchanger such that the water circulating therein exchanges heat with the refrigerant in the second heat exchanger.

In the first and second aspects of the present invention, the hybrid heat pump apparatus may further include a third heat exchanger connected to the water circulation pipe such that the water circulating in the water circulation pipe via the second heat exchanger exchanges heat with a heat source which is selectively supplied to the third heat exchanger.

In the first and second aspects of the present invention, the third heat exchanger may be connected to a hot water pipe which is selectively supplied with hot water, and the water circulating in the water circulation pipe may exchange heat with the hot water, as the heat source, flowing in the hot water pipe.

In the first and second aspects of the present invention, the hybrid heat pump apparatus may further include a third heat exchanger connected to the water circulation pipe such that the water circulating in the water circulation pipe via the second heat exchanger exchanges heat with a heat source which is selectively supplied to the third heat exchanger, the heating unit may include a hot water coil, the third heat exchanger may be connected to a hot water pipe which is selectively supplied with hot water, the water circulating in the water circulation pipe may exchange heat with the hot water, as the heat source, flowing in the hot water pipe, and a water inlet pipe into which hot water is introduced, a supply pipe of the hot water pipe connected to the third heat exchanger, and an inlet pipe connected to an inlet of the hot water coil may be interconnected by a three-way valve.

In the first aspect of the present invention, the hybrid heat pump apparatus may further include a first blower disposed in the first channel such that the first air forcibly passes through the first channel, and a second blower disposed in the second channel such that the second air forcibly passes through the second channel.

In the second aspect of the present invention, the hybrid heat pump apparatus may further include a first blower disposed in the first channel such that the first air forcibly passes through the first channel, a second blower disposed in the second channel such that the second air forcibly passes through the second channel, and a third blower disposed in the third channel such that the third air forcibly passes through the third channel.

In the first aspect of the present invention, the first or second blower may be selectively operated or stopped by a controller. In the second aspect of the present invention, the first, second, or third blower may be selectively operated or stopped by a controller.

In the first and second aspects of the present invention, at least a portion of the water circulation pipe may be disposed within at least one of an interior floor, an interior ceiling, and an interior wall.

In the first and second aspects of the present invention, at least a portion of the water circulation pipe may be disposed in a fan coil unit.

In the first and second aspects of the present invention, the first air may be air introduced into the first channel from the outside, and the first air passing through the first channel may be discharged to the outside.

In the first and second aspects of the present invention, the second air may be air introduced into the second channel from the outside, and the second air may be discharged to the outside after heat exchange in the first heat exchanger.

In the first and second aspects of the present invention, the hybrid heat pump apparatus may further include a water supply unit disposed in the second channel so as to spray water on a surface of the first heat exchanger.

In the first and second aspects of the present invention, the heating unit may include a hot water coil.

In the second aspect of the present invention, the third air may be air introduced into the third channel from the inside, and the third air passing through the third channel may be discharged to the inside.

In the second aspect of the present invention, the hybrid heat pump apparatus may further include a damper disposed between the second and third channels, the second channel communicating with the third channel by opening/closing of the damper.

In the second aspect of the present invention, the hybrid heat pump apparatus may further include an air filter disposed in the third channel.

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

Advantageous Effects

In accordance with the present invention, since a conventional dehumidifying and cooling technique is applied to a hybrid heat pump apparatus, the hybrid heat pump apparatus can have high energy efficiency and performs an eco-friendly cooling function. In addition, the hybrid heat pump apparatus can perform a heating function even when it does not include a separate heating apparatus.

In addition, when the heat pump apparatus is operated in a cooling mode, dehumidified and cooled air is used to condense a refrigerant without being supplied to the inside. In such a refrigerant circulation process, the water circulating in a water circulation pipe is cooled and the inside is cooled by means of the water circulation pipe in which the cooled water is circulated. Therefore, the hybrid heat pump apparatus can be applied to a structure for interior cooling even when it is not provided with a separate air circulation duct.

In addition, when the hot water supplied to a hot water coil during operation in the cooling mode or the hot water supplied through a hot water pipe during operation in the heating mode uses hot water heated by recycling waste heat, it is possible to improve energy efficiency.

In addition, when a defrost operation is required during operation in the heating mode, heating can be continuously performed without interruption. Therefore, it is possible to resolve inconvenience due to the interruption of heating.

Furthermore, since hot water and outdoor air are properly used as a heat source during operation in the heating mode, it is possible to efficiently realize required heating performance and thus to save energy.

DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram schematically illustrating a hybrid heat pump apparatus according to an embodiment of the present invention.

FIG. **2** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a cooling mode.

FIG. **3** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a first heating mode.

FIG. **4** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a defrost mode.

FIG. **5** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a second heating mode.

FIG. **6** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a third heating mode.

MODE FOR INVENTION

Hereinafter, a hybrid heat pump apparatus according to exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

FIG. **1** is a diagram schematically illustrating a hybrid heat pump apparatus according to an embodiment of the present invention.

As illustrated in FIG. **1**, the hybrid heat pump apparatus, which is designated by reference numeral **1**, according to the embodiment of the present invention includes a housing **100**, a desiccant rotor **101**, a heating unit **111**, a cooling unit **121**, a refrigerant circulation unit **140**, and a water circulation pipe **151**.

The housing **100** has first and second channels **110** and **120** formed therein in the state in which they are partitioned by a partition wall **102**, air passing through the first and second channels **110** and **120**.

The air passing through the first channel **110** may be defined as first air. The first air may be, for instance, air introduced into the first channel **110** from the outside. The first air may be discharged to the outside after passing through the first channel **110**.

The heating unit **111** is disposed in the first channel **110**. In this case, the heating unit **111** is disposed upstream of the desiccant rotor **101**, which will be described in detail later, so as to be closer to the introduction side of the first air, namely, is disposed closer to the left of the first channel **110** in the drawing. The first air passing through the first channel **110** passes through the desiccant rotor **101** via the heating unit **111**.

The heating unit **111** may include, for instance, a heat coil so as to provide heat using electric resistance. Alternatively, the heating unit **111** may include, for instance, a hot water coil **113** so as to provide heat using hot water.

When the heating unit **111** includes the hot water coil **113**, an inlet pipe **114** may be formed at the inlet of the hot water coil **113**. An outlet pipe **115** may be formed at the outlet of the hot water coil **113**.

The inlet pipe **114** is connected to a water inlet pipe **50**. The hot water supplied through the water inlet pipe **50** is supplied to the hot water coil **113** through the inlet pipe **114**, and is then discharged through the outlet pipe **115** after flowing in the hot water coil **113**.

Here, the hot water supplied through the water inlet pipe **50** may be hot water for district heating, which is heated using waste heat generated when electricity is generated in a factory or a cogeneration plant. In this case, it is possible to efficiently use energy by recycling waste heat.

The first air passing through the heating unit **111** is heated by heat exchange with the hot water flowing in the hot water coil **113**. The first air heated by the heating unit **111** dries the desiccant rotor **101** while passing through the desiccant rotor **101**.

The desiccant rotor **101** is rotatably disposed in the housing **100**. The desiccant rotor **101** is disposed over the first and second channels **110** and **120**.

The desiccant rotor **101** has an absorbent, such as silica gel or zeolite, which is formed on the contact surface with air, and may absorb moisture from the air passing therethrough.

The air passing through the second channel **120** may be defined as second air. The second air may be, for instance, air introduced from the outside. The second air is dehumidified by the desiccant rotor **101** while passing through the desiccant rotor **101**.

The cooling unit **121** is disposed in the second channel **120**. In this case, the cooling unit **121** is disposed downstream of the desiccant rotor **101** so as to be closer to the discharge side of the second air, namely, is disposed closer to the left of the second channel **120** in the drawing. The second air passing through the second channel **120** passes through the cooling unit **121** via the desiccant rotor **101**.

The cooling unit **121** cools the second air which is dehumidified by passing through the desiccant rotor **101**. The cooling unit **121** may be, for instance, an evaporative cooler which sprays water on second air passing therethrough so as to cool the second air in the process of evaporating the sprayed water.

The second air is selectively cooled by operating the cooling unit **121** to spray water or stopping the operation of the cooling unit **121** by a controller. In other words, when the cooling unit **121** is controlled to be operated by the controller, the second air passing through the cooling unit **121** is cooled by the cooling unit **121**. However, when the operation of the cooling unit **121** is stopped by the controller, the second air passing through the cooling unit **121** is not cooled.

Although described in more detail later, when the heat pump apparatus **1** according to the embodiment is operated in a heating mode, the operation of the cooling unit **121** is stopped. Consequently, the second air, which has passed through the desiccant rotor **101**, is not cooled, but flows to a first heat exchanger **142** to be described later.

The refrigerant circulation unit **140** constitutes a circuit in which a refrigerant is circulated. The refrigerant circulation unit **140** includes a compressor **141** which compressed a refrigerant, a first heat exchanger **142** in which a refrigerant is condensed or evaporated by heat exchange, and a second heat exchanger **144** in which a refrigerant is evaporated or condensed by heat exchange.

In this case, the first heat exchanger **142** is disposed in the second channel **120**. The first heat exchanger **142** is disposed downstream of the cooling unit **121** so as to be closer to the discharge side of the second air.

An expansion valve **143** for expanding a refrigerant may be disposed between the first and second heat exchangers **142** and **144**.

The refrigerant circulation unit **140** includes a four-way valve **145** for changing the circulation direction of a refrigerant when the operation mode of the heat pump apparatus **1** is switched to a cooling mode or a heating mode. The four-way valve **145** is controlled by the controller and serves to change the circulation direction of a refrigerant.

For example, when the heat pump apparatus **1** is operated in the cooling mode, a refrigerant may be circulated so as to return to the compressor **141** after passing through the compressor **141**, the first heat exchanger **142**, the expansion valve **143**, and the second heat exchanger **144**. In this case, the first heat exchanger **142** functions as a condenser, and the second heat exchanger **144** functions as an evaporator.

For example, when the heat pump apparatus **1** is operated in the heating mode, a refrigerant may be circulated so as to return to the compressor **141** after passing through the compressor **141**, the second heat exchanger **144**, the expansion valve **143**, and the first heat exchanger **142**. In this case, the first heat exchanger **142** functions as an evaporator, and the second heat exchanger **144** functions as a condenser.

Meanwhile, in order to further lower the condensation temperature of the refrigerant in the first heat exchanger **142** functioning as a condenser during operation in the cooling mode, the heat pump apparatus **1** according to the embodiment may further include a water supply unit **123** which sprays water on the first heat exchanger **142**.

The water supply unit **123** is disposed in the second channel **120**, and may be controlled such that the water supply unit **123** is operated or the operation thereof is stopped by the controller.

When water is sprayed on the surface of the first heat exchanger **142** by the operation of the water supply unit **123**, the heat of the second air passing through the second channel **120** is absorbed as the evaporative latent heat of the water sprayed on the surface of the first heat exchanger **142** so that the second air is further cooled. Therefore, the condensation temperature of the refrigerant, which exchanges heat with the second air, is further lowered, and it is thus possible to increase condensing efficiency.

However, during operation in the heating mode in which the first heat exchanger **142** functions as an evaporator, the operation of the water supply unit **123** is stopped by the controller.

The water circulation pipe **151** is a pipe through which water is circulated, and is connected to the second heat exchanger **144**. The second heat exchanger **144** may be a plate-type heat exchanger. The water circulating through the water circulation pipe **151** may exchange heat with the refrigerant in the second heat exchanger **144**.

As described above, the second heat exchanger **144** serves as an evaporator or a condenser according to the control of the four-way valve **145**.

When the second heat exchanger **144** functions as an evaporator, the water circulating in the water circulation pipe **151** is cooled by heat exchange in the second heat exchanger **144**. The water circulation pipe **151**, in which the cooled water is circulated, may be used to cool the inside of a structure.

When the second heat exchanger **144** functions as a condenser, the water circulating in the water circulation pipe **151** is heated by heat exchange in the second heat exchanger **144**. The water circulation pipe **151**, in which the heated water is circulated, may be used to heat the inside of a structure.

Meanwhile, when the heat pump apparatus **1** is operated in the heating mode, the heat pump apparatus **1** according to the embodiment may further include a third heat exchanger **161** such that the water in the water circulation pipe **151**, which is heated by heat exchange in the second heat exchanger **144**, may be further heated.

The third heat exchanger **161** is connected to the water circulation pipe **151**. The water circulating in the water circulation pipe **151** passes through the third heat exchanger **161** via the second heat exchanger **144**. The water circulating in the water circulation pipe **151** may be heated by heat exchange with a heat source supplied to the third heat exchanger **161**. The heat source may be, for instance, hot water.

In more detail, the third heat exchanger **161** may be connected to a hot water pipe **170**. The water circulating in the water circulation pipe **151** may be heated by heat exchange with the hot water flowing through the hot water pipe **170** in the third heat exchanger **161**.

In this case, the third heat exchanger **161** may be a plate-type heat exchanger, similar to the second heat exchanger **144**.

Meanwhile, since the heat exchange in the third heat exchanger **161** is performed during operation in the heating mode, the heat source supplied to the third heat exchanger **161** is supplied only during operation in the heating mode whereas it is not supplied during operation in the cooling mode.

That is, the supply of hot water through the hot water pipe **170** is selectively performed. For example, hot water may be controlled by the opening/closing of a valve for allowing or blocking the supply of hot water to the hot water pipe **170** so that the hot water is supplied to the hot water pipe **170** only during operation in the heating mode whereas it is not supplied thereto during operation in the cooling mode.

In this case, a supply pipe **171** of the hot water pipe **170** connected to the third heat exchanger **161** may be connected to the water inlet pipe **50** in order to supply hot water thereto. In this case, the water inlet pipe **50**, the supply pipe **171** of the hot water pipe **170**, and the inlet pipe **114** connected to the inlet of the hot water coil **113** may be interconnected by a three-way valve **51**.

The hot water introduced through the water inlet pipe **50** may be supplied to the hot water coil **113** through the inlet pipe **114**, or to the third heat exchanger **161** through the supply pipe, according to the control of the three-way valve **51**. Alternatively, the hot water may not be supplied to both of the inlet pipe **114** and the supply pipe **171** according to the control of the three-way valve **51**.

The water circulating in the water circulation pipe **151** is cooled or heated by passing through the second heat exchanger **144** or the second and third heat exchangers **144** and **161** depending on the operation mode of the heat pump apparatus **1**. The water circulation pipe **151**, in which the cooled or heated water is circulated, may be utilized for interior cooling or heating, and a specific example thereof is as follows.

Although not illustrated in the drawing, at least a portion of the water circulation pipe **151** may be disposed within any one of an interior floor, an interior ceiling, and an interior wall. The inside may be cooled or heated in a panel cooling or heating manner by disposing the water circulation pipe **151** within the interior floor, the interior ceiling, or the interior wall.

Alternatively, a portion of the water circulation pipe **151** may be is disposed in a fan coil unit **180** which is arranged inside a structure, as illustrated in the drawing, and the inside of the structure may be cooled or heated by operating the fan coil unit **180**.

Meanwhile, the first air may forcibly pass through the first channel **110** by operating a first blower **112** disposed in the first channel **110**. Similarly, the second air may forcibly pass through the second channel **120** by operating a second blower **122** disposed in the second channel **120**.

Each of the first and second blowers **112** and **122** may be controlled to be operated or stopped by a controller (not shown).

The heat pump apparatus **1** according to the embodiment may further include a third channel **130** which is formed in the housing **100** and through which air passes. The second and third channels **120** and **130** may be partitioned from each other by a partition wall **103** in the housing **100**.

When the third channel **130** is further formed in the housing **100**, the desiccant rotor **101** is disposed over the first to third channels **110** to **130** in the housing **100**, as illustrated in the drawing.

A cooling unit **131** is disposed in the third channel **130**. The cooling unit **131** is disposed downstream of the desiccant rotor **101** so as to be closer to the discharge side of third air, namely, is disposed closer to the left of the third channel **130** in the drawing.

The air passing through the third channel **130** may be defined as third air. The third air may be air introduced into the third channel **130** from the inside.

The third channel **130** may be connected to an interior ventilation duct, which is formed in a structure, such that indoor air is introduced into the third channel **130** and is then supplied back to the inside. The air introduced into the third channel **130** may be dehumidified and cooled while sequentially passing through the desiccant rotor **101** and the cooling unit **131**. After the third air is cooled, the third air may be supplied back to the inside so as to dehumidify and cool the inside.

An air filter **133** may be disposed in the third channel **130** so as to remove dust, foreign substances, and the like in the third air passing through the third channel **130**.

A third blower **132**, which allows the third air to forcibly pass through the third channel **130**, may be disposed in the third channel **130**. The third blower **132** may be controlled so as to be operated or stopped by the controller, similar to the first and second blowers **112** and **122**.

The controller may control the blowers such that only the first and second blowers **112** and **122** are operated, or may control the blowers such that all of the first to third blowers **112** to **132** are operated for interior cooling and dehumidification as occasion demands. Alternatively, the controller may control the blowers such that the first and second blowers **112** and **122** are stopped and only the third blower **132** is operated.

Meanwhile, in order to ventilate the inside when the heat pump apparatus **1** is operated in the cooling mode, the heat pump apparatus **1** according to the embodiment may further include a damper **191** disposed between the second and third channels **120** and **130**.

The damper **191** allows the second channel **120** to selectively communicate with the third channel **130** depending on the opening/closing thereof. As illustrated in the drawing, when the damper **191** is opened, a portion of the outdoor air introduced into the second channel **120** may flow into the third channel **130**, and a portion of the indoor air into the third channel **130** may be discharged to the second channel **120**.

Consequently, the air supplied to the inside through the third channel **130** is a mixture (mixed air) of indoor air and outdoor air. The inside may be ventilated by supplying the mixed air thereto.

Hereinafter, the state for each operation mode of the heat pump apparatus **1** according to the embodiment will be described with reference to FIGS. **2** to **6**.

FIG. **2** is a diagram illustrating a state in which the heat pump apparatus **1** illustrated in FIG. **1** is operated in the cooling mode.

As illustrated in the drawing, the hot water introduced into the water inlet pipe **50** flows only to the hot water coil **113** according to the control of the three-way valve **51** during operation in the cooling mode.

The first air passing through the first channel **110** is heated by the heating unit **111** including the hot water coil **113**, and the heated first air dries the desiccant rotor **101** while passing through the desiccant rotor **101** which is rotating. The first air, which has passed through the desiccant rotor **101**, is discharged to the outside.

The second air introduced into the second channel **120** from the outside is dehumidified while passing through the desiccant rotor **101** which is rotating. In the process in which the desiccant rotor **101** rotates, the desiccant rotor **101**, which absorbs moisture from the second air, is dried by the first air, which is heated by passing through the first channel **110**, and is regenerated again.

The second air, which is dehumidified by passing through the desiccant rotor **101**, is cooled while passing through the cooling unit **121**. The cooled second air flows to the first heat exchanger **142**. In this case, the refrigerant compressed by the compressor **141** is circulated to the first heat exchanger **142** according to the control of the four-way valve **145**.

The cooled second air condenses a refrigerant while passing through the first heat exchanger **142**, and is then discharged to the outside.

In this case, when the water supply unit **123** is controlled to be operated by the controller, water is sprayed on the surface of the first heat exchanger **142**, and the heat of the second air passing through the first heat exchanger **142** is absorbed as the evaporative latent heat of the water sprayed on the surface of the first heat exchanger **142** so that the second air is further cooled. Consequently, the condensation temperature of the refrigerant circulating in the first heat exchanger **142** may be further lowered, and it is thus possible to further reduce the power consumption of the compressor **141**.

The refrigerant condensed by the first heat exchanger **142** is circulated to the second heat exchanger **144** via the expansion valve **143**.

The water circulating in the water circulation pipe **151** is cooled by heat exchange with the refrigerant in the second heat exchanger **144**. A portion of the water circulation pipe **151**, in which the cooled water is circulated, is disposed in the fan coil unit **180**, thereby enabling the inside to be cooled by the operation of the fan coil unit **180**.

In this case, when the heat pump apparatus **1** according to the embodiment further includes the third channel **130** as described above, the third air, which is dehumidified and cooled by passing through the third channel **130**, is supplied back to the inside by operating the third blower **132**, thereby enabling the inside to be cooled and dehumidified.

In addition, a portion of indoor air is discharged to the outside through the second channel **120** while a portion of outdoor air is supplied to the inside through the third channel **130** by opening the damper **191**, as illustrated in the drawing, thereby enabling the inside to be ventilated.

FIGS. **3**, **5**, and **6** are diagrams illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in various operation modes.

FIG. **3** is a diagram illustrating a state in which the heat pump apparatus is operated in a first heating mode. In this case, the supply of hot water to the hot water coil **113** and the third heat exchanger **161** is blocked according to the control of the three-way valve **51**.

The introduction of air into the first and third channels **110** and **130** is blocked by stopping the operation of the first and third blowers **112** and **132**. The damper **191** is closed.

Outdoor air is introduced into the second channel **120** by the operation of the second blower **122**, and the introduced outdoor air flows to the first heat exchanger **142** after passing through the desiccant rotor **101**. In this case, the operation of the cooling unit **121** is stopped such that the outdoor air, which has passed through the desiccant rotor **101**, is not cooled.

A refrigerant is circulated in a direction opposite to that during operation in the cooling mode according to the control of the four-way valve **145** in the refrigerant circulation unit **140**. That is, the refrigerant compressed by the compressor **141** is circulated to the second heat exchanger **144**, and is then circulated to the first heat exchanger **142** via the expansion valve **143**.

The refrigerant circulating in the first heat exchanger **142** is evaporated by heat exchange with the second air, and is then introduced into the compressor **141** to be compressed therein. The refrigerant compressed by the compressor **141** is circulated to the second heat exchanger **144**, in which case the second heat exchanger **144** functions as a condenser so that the water circulating in the water circulation pipe **151** is heated by heat exchange in the second heat exchanger **144**.

A portion of the water circulation pipe **151**, in which the heated water is circulated, is disposed in the fan coil unit **180**, thereby enabling the inside to be heated by the operation of the fan coil unit **180**.

FIG. **4** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a defrost mode.

Frost may occur in the first heat exchanger **142** which functions as an evaporator during operation in the first heating mode. In this case, the heat pump apparatus **1** may be operated in the defrost mode in order to remove frost.

When the heat pump apparatus is operated in the defrost mode, the whole operation of the first to third blowers **112** to **132** is stopped.

The hot water introduced into the water inlet pipe **50** is supplied to the third heat exchanger **161** through the hot water pipe **170** according to the control of the three-way valve **51**. The water circulating in the water circulation pipe **151** is heated by heat exchange in the third heat exchanger **161**. Thus, it is possible to heat the inside by operating the fan coil unit **180**.

The water circulating in the water circulation pipe **151** passes through the second heat exchanger **144** via the fan coil unit **180**.

In this case, the refrigerant circulating in the refrigerant circulation unit **140** is circulated in the same direction as a direction, in which a refrigerant is circulated during operation in the cooling mode, according to the control of the four-way valve **145**.

The second heat exchanger **144** functions as an evaporator, and the water, which is heated while passing through the second heat exchanger **144** in the water circulation pipe, evaporates the refrigerant circulating in the second heat exchanger **144**.

The evaporated refrigerant is introduced into the compressor **141** to be compressed therein, and is then circulated to the first heat exchanger **142**. The refrigerant circulating in the first heat exchanger **142** exchanges heat with the frost formed on the first heat exchanger **142**. In this process, the frost is heated and removed.

The heat pump apparatus **1** according to the embodiment can perform interior heating without interruption even when it is operated in the defrost mode.

FIG. **5** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a second heating mode.

The heat pump apparatus **1** according to the embodiment performs interior heating by directly using hot water supplied from the outside. Here, the hot water may be hot water for district heating, which is heated by recycling waste heat, as described above.

Similarly to operation in the defrost mode illustrated in FIG. **4**, the water circulating in the water circulation pipe **151** is heated by heat exchange with the hot water supplied through the hot water pipe **170** in the third heat exchanger **161** in the second heating mode.

The heated water passes through the fan coil unit **180**, and the inside may be heated by the operation of the fan coil unit **180**.

However, the operation in the second heating mode differs from the operation in the defrost mode illustrated in FIG. **4** in that the operation of the refrigerant circulation unit **140** is stopped.

FIG. **6** is a diagram illustrating a state in which the heat pump apparatus illustrated in FIG. **1** is operated in a third heating mode.

In the third heating mode, the operation of the first and third blowers **112** and **132** is stopped, and only the second blower **122** is operated, so that outdoor air is introduced into the second channel **120**. In this case, the cooling unit **121** is maintained in the state in which the operation thereof is stopped.

The refrigerant circulating in the refrigerant circulation unit **140** is circulated in the same direction as a direction, in which a refrigerant is circulated during operation in the first heating mode, according to the control of the four-way valve **145**. Accordingly, the first heat exchanger **142** functions as an evaporator for evaporating a refrigerant using the outdoor air, which passes through the second channel **120**, as a heat source.

The refrigerant evaporated in the first heat exchanger **142** is compressed by the compressor **141**, and is then circulated to the second heat exchanger **144**. In this case, the second heat exchanger **144** functions as a condenser. The water circulating in the water circulation pipe **151** is primarily heated while passing through the second heat exchanger **144**.

The primarily heated water in the water circulation pipe **151** passes through the third heat exchanger **161**. Hot water is supplied to the third heat exchanger **161** through the hot water pipe **170** according to the control of the three-way valve **51**. The primarily heated water in the water circulation pipe **151** is secondarily heated by heat exchange with the hot water in the third heat exchanger **161**.

The secondarily heated water passes through the fan coil unit **180**. Thus, interior heating can be performed by the operation of the fan coil unit **180**.

Since the water circulating in the water circulation pipe **151** is heated twice while passing through the second and third heat exchangers **144** and **161** in the third heating mode, it is possible to rapidly heat water. The heat pump apparatus **1** can rapidly perform interior heating when it is operated in the third heating mode.

Although the present invention has been described with respect to the illustrative embodiments, it should be understood that numerous other modifications and applications may be devised by those skilled in the art that will fall within the intrinsic aspects of the embodiments. More particularly, various variations and modifications are possible in concrete constituent elements of the embodiments.

In addition, it is to be understood that differences relevant to the variations and modifications fall within the spirit and scope of the present disclosure defined in the appended claims.

[Description of Reference Numerals]

1: heat pump apparatus	50: water inlet pipe
51: three-way valve	100: housing
101: desiccant rotor	102, 103: partition wall
110: first channel	111: heating unit
112: first blower	113: hot water coil
114: inlet pipe	115: outlet pipe
120: second channel	121: cooling unit
122: second blower	123: water supply unit
130: third channel	131: cooling unit
132: third blower	133: air filter
140: refrigerant circulation unit	141: compressor
142: first heat exchanger	143: expansion valve
144: second heat exchanger	145: four-way valve
151: water circulation pipe	161: third heat exchanger
170: hot water pipe	171: supply pipe
180: fan coil unit	191: damper

The invention claimed is:

1. A hybrid heat pump apparatus comprising:
- a housing;
- a first channel formed in the housing such that first air passes through the first channel;
- a second channel formed in the housing such that second air passes through the second channel;
- a desiccant rotor rotatably installed in the housing while being disposed over the first and second channels, so that the desiccant rotor is dried by the first air passing therethrough and absorbs moisture from the second air passing therethrough;
- a heating unit disposed upstream of the desiccant rotor so as to be closer to an introduction side of the first air in the first channel, the heating unit serving to heat the first air passing therethrough;
- a cooling unit disposed downstream of the desiccant rotor so as to be closer to a discharge side of the second air in the second channel, the cooling unit serving to selectively cool the second air passing therethrough;
- a refrigerant circulation unit comprising a compressor, a first heat exchanger, a second heat exchanger, and a four-way valve, the first heat exchanger being disposed downstream of the cooling unit so as to be closer to the discharge side of the second air in the second channel, a refrigerant being circulated in the refrigerant circulation unit in order of the compressor, the first heat exchanger, the second heat exchanger, and the compressor or vice versa, according to control of the four-way valve; and
- a water circulation pipe in which water is circulated, the water circulation pipe being connected to the second heat exchanger such that the water circulating therein exchanges heat with the refrigerant in the second heat exchanger.

2. A hybrid heat pump apparatus comprising:
- a housing;
- a first channel formed in the housing such that first air passes through the first channel;
- a second channel formed in the housing such that second air passes through the second channel;
- a third channel formed in the housing such that third air passes through the third channel;
- a desiccant rotor rotatably installed in the housing while being disposed over the first, second, and third channels, so that the desiccant rotor is dried by the first air passing therethrough and absorbs moisture from the second air and the third air passing therethrough;
- a heating unit disposed upstream of the desiccant rotor so as to be closer to an introduction side of the first air in the first channel, the heating unit serving to heat the first air passing therethrough;
- a first cooling unit disposed downstream of the desiccant rotor so as to be closer to a discharge side of the second air in the second channel, the first cooling unit serving to selectively cool the second air passing therethrough;
- a second cooling unit disposed downstream of the desiccant rotor so as to be closer to a discharge side of the third air in the third channel, the second cooling unit serving to cool the third air passing therethrough;
- a refrigerant circulation unit comprising a compressor, a first heat exchanger, a second heat exchanger, and a four-way valve, the first heat exchanger being disposed downstream of the first cooling unit so as to be closer to the discharge side of the second air in the second channel, a refrigerant being circulated in the refrigerant circulation unit in order of the compressor, the first heat exchanger, the second heat exchanger, and the compressor or vice versa, according to control of the four-way valve; and
- a water circulation pipe in which water is circulated, the water circulation pipe being connected to the second heat exchanger such that the water circulating therein exchanges heat with the refrigerant in the second heat exchanger.

3. The hybrid heat pump apparatus of claim **1**, further comprising a third heat exchanger connected to the water circulation pipe such that the water circulating in the water circulation pipe via the second heat exchanger exchanges heat with a heat source which is selectively supplied to the third heat exchanger.

4. The hybrid heat pump apparatus of claim **3**, wherein the third heat exchanger is connected to a hot water pipe which is selectively supplied with hot water, and the water circulating in the water circulation pipe exchanges heat with the hot water, as the heat source, flowing in the hot water pipe.

5. The hybrid heat pump apparatus of claim **1**, further comprising a third heat exchanger connected to the water circulation pipe such that the water circulating in the water circulation pipe via the second heat exchanger exchanges heat with a heat source which is selectively supplied to the third heat exchanger, wherein:
- the heating unit comprises a hot water coil;

the third heat exchanger is connected to a hot water pipe which is selectively supplied with hot water, and the water circulating in the water circulation pipe exchanges heat with the hot water, as the heat source, flowing in the hot water pipe; and

a water inlet pipe into which hot water is introduced, a supply pipe of the hot water pipe connected to the third heat exchanger, and an inlet pipe connected to an inlet of the hot water coil are interconnected by a three-way valve.

6. The hybrid heat pump apparatus of claim **1**, further comprising a blower disposed in the first or second channel such that air forcibly passes through the first or second channel.

7. The hybrid heat pump apparatus of claim **2**, further comprising a blower disposed in the first, second, or third channel such that air forcibly passes through the first, second, or third channel.

8. The hybrid heat pump apparatus of claim **1**, wherein at least a portion of the water circulation pipe is disposed within at least one of an interior floor, an interior ceiling, and an interior wall.

9. The hybrid heat pump apparatus of claim **1**, wherein at least a portion of the water circulation pipe is disposed in a fan coil unit.

10. The hybrid heat pump apparatus of claim **1**, wherein the first air is air introduced into the first channel from the outside, and the first air passing through the first channel is discharged to the outside.

11. The hybrid heat pump apparatus of claim **1**, wherein the second air is air introduced into the second channel from the outside, and the second air is discharged to the outside after heat exchange in the first heat exchanger.

12. The hybrid heat pump apparatus of claim **1**, further comprising a water supply unit disposed in the second channel so as to spray water on a surface of the first heat exchanger.

13. The hybrid heat pump apparatus of claim **1**, wherein the heating unit comprises a hot water coil.

14. The hybrid heat pump apparatus of claim **2**, wherein the third air is air introduced into the third channel from the inside, and the third air passing through the third channel is discharged to the inside.

15. The hybrid heat pump apparatus of claim **2**, further comprising a damper disposed between the second and third channels, the second channel communicating with the third channel by opening/closing of the damper.

16. The hybrid heat pump apparatus of claim **2**, further comprising an air filter disposed in the third channel.

17. The hybrid heat pump apparatus of claim **2**, further comprising a third heat exchanger connected to the water circulation pipe such that the water circulating in the water circulation pipe via the second heat exchanger exchanges heat with a heat source which is selectively supplied to the third heat exchanger.

18. The hybrid heat pump apparatus of claim **17**, wherein the third heat exchanger is connected to a hot water pipe which is selectively supplied with hot water, and the water circulating in the water circulation pipe exchanges heat with the hot water, as the heat source, flowing in the hot water pipe.

19. The hybrid heat pump apparatus of claim **2**, further comprising a third heat exchanger connected to the water circulation pipe such that the water circulating in the water circulation pipe via the second heat exchanger exchanges heat with a heat source which is selectively supplied to the third heat exchanger, wherein:

the heating unit comprises a hot water coil;

the third heat exchanger is connected to a hot water pipe which is selectively supplied with hot water, and the water circulating in the water circulation pipe exchanges heat with the hot water, as the heat source, flowing in the hot water pipe; and

a water inlet pipe into which hot water is introduced, a supply pipe of the hot water pipe connected to the third heat exchanger, and an inlet pipe connected to an inlet of the hot water coil are interconnected by a three-way valve.

20. The hybrid heat pump apparatus of claim **2**, wherein at least a portion of the water circulation pipe is disposed within at least one of an interior floor, an interior ceiling, and an interior wall.

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